Phys 131 2016

Lecture 34

Thurs: Physics Seminar

Fri: HW by 5pm

Ch 12 Conc Q 6, 9, 10

Prob 15, 31, 53, 57, 59

Rotational dynamics.

Specify forces and a pivot

⟹

Determine torque produced by each force

$$\tau = rF\sin\phi$$

and compute net torque

$$\tau_{net} = \tau_1 + \tau_2 + \ldots$$

⟹

Determine moment of inertia

$$I = \sum m_i r_i^2$$

⟹

Rotational version of Newton's 2nd law:

$$\tau_{net} = I\alpha$$

gives angular acceleration

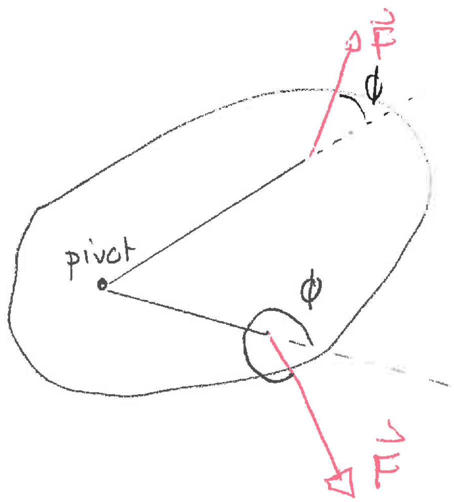
⟹

Determines changes in angular velocity

Thus:

Torque does not directly determine angular velocity. Torque does determine rate of change of angular velocity.

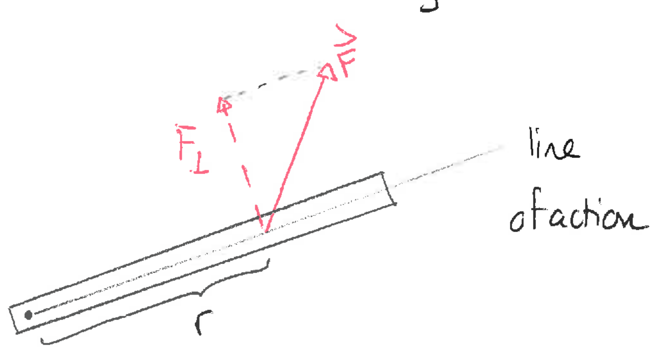
Note, when computing the torque the construction involves drawing a line from the pivot to the point where the force acts. Then extend this to get the angle.



Quiz 1

Quiz 2

Note that there are other ways to calculate torque. One can construct a line of action from the pivot to the force.



Then the torque is

$$\boxed{\tau = r F_\perp}$$

where $F_\perp$ is the component of $\vec{F}$ perpendicular to the line of action

Equilibrium

In static equilibrium, an object is either

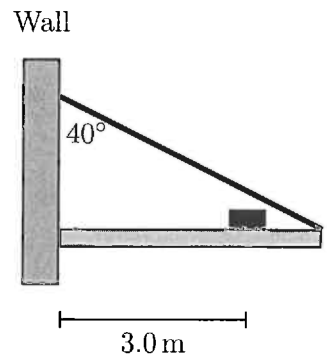
a) at rest

b) moves with constant angular velocity about the c.o.m. and the c.o.m moves with constant velocity

In such cases Newton's 2nd Laws state:

$$\boxed{\text{Object is in equilibrium} \iff \tau_{net} = 0 \text{ and } \vec{F}_{net} = 0}$$

73 Beam in equilibrium



A 4.0 m long, 80 kg beam is anchored to a wall and held at rest horizontally by a rope at the illustrated angle. A 10 kg box rests on the beam at the illustrated point. The aim of this exercise is to determine the tension in the rope. This would enable one to decide on the breaking strength of the rope.

a) State the conditions for equilibrium.

b) Draw all the force vectors on the beam.

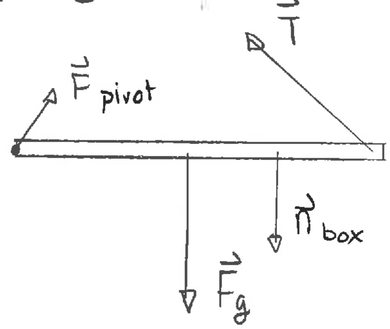
c) Identify a pivot point (there are many correct possibilities – one is much more useful than the others) and determine expressions for the torque exerted by each force about the pivot.

d) Substitute the individual torques into one of the conditions for equilibrium and obtain an expression for the tension in the rope.

Answer:

a) $\tau_{net} = 0$ $\quad\quad \vec{F}_{net} = 0$

b)



$n_{box} = m_{box}\, g$

$= 10kg \times 9.8 m/s^2$

$n_{box} = 98N$

$F_g = M_{beam}\, g$

$= 80kg \times 9.8 m/s^2 = 780N$

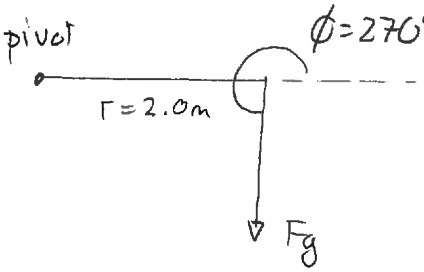
c) Use anchor. Then

$\tau_{pivot} = r F_{pivot} \sin\phi$

$= 0\, N\cdot m$ since $r = 0$.

$\tau_{pivot} = 0\, N.m$

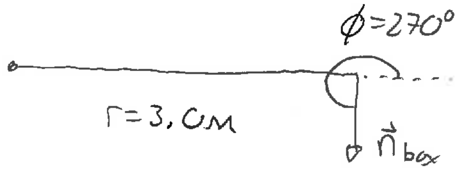
gravity



$\tau_g = r F_g \sin\phi = 2.0m \times 780N \times \sin 270°$

$\tau_g = -1560 N \cdot m$

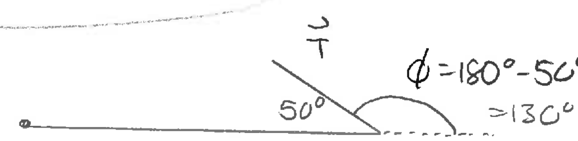
box



$\tau_{box} = r n_{box} \sin\phi = 3.0m \times 98N \times \sin 270°$

$\tau_{box} = -290 N \cdot m$

rope



$\tau_{rope} = r F \sin\phi = 4.0m \; T \sin 130°$

$\tau_{rope} = 3.06 \, m \, T$

d) $\tau_{net} = 0 \Rightarrow \tau_{pivot} + \tau_g + \tau_{box} + \tau_{rope} = 0$

$0 N\cdot m - 1560 N\cdot m - 290 N\cdot m + 3.06m\,T = 0$

$\Rightarrow 3.06m\,T = 1850 N\cdot m$

$\Rightarrow T = \dfrac{1850 N\cdot m}{3.06m} \Rightarrow T = 600 N$